SEDIMENT AND WATER QUALITY

Coastal ecosystems are one of the most important resources of the Commonwealth of Massachusetts as they support a diversity of resources and human uses, such as rich nursery and fishing grounds, tourism, and shipping. They are also threatened by growing populations in coastal regions and the myriad of point-source and non-point source pollution problems associated with growing population centers. Numerous recent reports highlighted the concerns of excessive nutrient discharges and other contaminant inputs to coastal waters and the need to better understand such problems before these threats lead to deterioration of coastal ecosystems (NRC 1994; Howarth et. al 1996; Boesch et al. 2001).

1. WATER QUALITY IN MASSACHUSETTS COASTAL ZONE & SUMMARY OF MONITORING ACTIVITIES

Environmental quality of U.S. coastal waters continues to be a major concern as population centers continue to grow in coastal regions and effluent discharges from multiple sources enter the sea. Input of nutrients to coastal waters leading to eutrophication is one of the most serious concerns facing coastal managers as this problem increases on local and global scales. In spite of advances in wastewater treatment over the past two decades, non-point sources of contamination continue to present a challenge to managing coastal waters. In a recent report issued by the Pew Oceans Commission on marine pollution, a watershed approach to managing coastal waters was recommended as the best way to integrate management and monitoring of multiple point and non-point sources of nutrient input.

Massachusetts DEP

The Massachusetts Department of Environmental Protection (DEP), through its Division of Watershed Management, is responsible for monitoring the condition of the water resources of the Commonwealth to identify whether ambient waters are of sufficient quality and quantity to support multiple uses, and to report findings in watershed assessment reports; to identify causes and sources of water use impairments as a first step in identifying water management strategies; and to characterize existing and emerging problems and target implementation strategies. For coastal monitoring, DEP collaborates with other federal and state agencies, as well as local entities, including the National Estuaries Program, the MWRA, and the Massachusetts Office of Coastal Zone Management (CZM). Massachusetts has initiated a Marine Monitoring and Research Program (MMRP). Much of CZM's initial emphasis has been placed on gaining information necessary to implement Best Management Practices for the improvement of the ecosystem health of coastal embayments.

National Estuaries Programs

Coastal Massachusetts has benefited from several major initiatives in coastal water quality management through the National Estuaries Program. The Buzzards Bay Program and the Massachusetts Bay Program have comprehensive management plans developed for identifying and addressing water quality problems and their solutions. The Buzzards Bay Program was one of the first estuaries to be designated in the National

Estuaries Program. From a water quality perspective, the greatest concern in the Buzzards Bay watershed is the nutrient and pathogen input from residential developments into small embayments through run-off and groundwater input. The Coalition for Buzzards Bay, a nonprofit organization, developed as a citizen-led advocacy, education and research group to facilitate implementation of the comprehensive management plan and improve the involvement and education of local citizens and town officials in understanding the Buzzards Bay watershed. The Coalition releases an annual State of the Bay report with recommendations for improving and restoring degraded areas of the watershed.

The Massachusetts Bays Estuary Program was designated in the late 1980s and was closely aligned with the court mandated improvements in wastewater treatment for the City of Boston and surrounding cities and towns. The coastal area covered by the program extends from the New Hampshire border to the tip of Cape Cod and includes five distinct regions – eight Towns on the North Shore, Salem Sound, Metro Boston, South Shore and Cape Cod. Each of these regions has a unique set of management issues but they also share similar goals in the action plan to improve water quality over the next decade. Current program efforts are directed at a better integration of monitoring programs throughout the region and tracking the implementation of different aspects of the comprehensive management plan.

Although the Narragansett Bay Project is largely based in Rhode Island and directed at improving the water quality of the bay proper, several Massachusetts communities are located in the Narragansett Bay watershed. Communities on Mt. Hope Bay share many of the concerns in water quality seen in Buzzards Bay and Massachusetts Bays. The recent establishment of the Mt. Hope Bay Project at the University of Massachusetts at Dartmouth is directed at a better understanding of nutrient loading and habitat loss in Mt. Hope Bay. This project should add valuable insights on the status of Mt. Hope Bay in relation to other coastal regions of Massachusetts.

Massachusetts Division of Marine Fisheries Water Temperature Monitoring

MarineFisheries has monitored bottom water temperature from 1982 to present to examine the effect of water temperature on lobster biology. This monitoring program has specific goals related to the American lobster but is also an important dataset for a variety of purposes. Water temperature is collected with programmable electronic recorders at various depths at nine coastal sites located north and south of Cape Cod. Monitors are exchanged annually via SCUBA and the data downloaded for analysis. The temporal starting point for each site's time series differs since monitors were purchased and deployed as funding allowed.

The longest time series of bottom temperatures is from Cleveland Ledge in Buzzards Bay that is located at 30 ft. The last monitor to be deployed in this series was at Rocky Point, off Plymouth, also in the 30 ft. stratum. The Manomet Point and Mars sites located in Cape Cod Bay are at 60 ft. and 120 ft. respectively. The Martin's Ledge (formerly at the *Romance* wreck site) off Boston Harbor and Buzzards Bay-South (Barge) sites are located at 70-80 ft. and provide data from the north-south extremes in our series. Three sites (<20') were added in summer 2001 at early benthic phase lobster suction sampling stations in Boston Harbor, Cape Cod Bay and Buzzards Bay.

To determine if there have been any trends in bottom water temperature in Massachusetts coastal waters over time, deviations from the seasonal time series mean temperature were calculated and plotted. Two sites, one shallow and one deep, that are representative of the range of water depths that are typically fished in the Massachusetts coastal lobster fishery were chosen north and south of Cape Cod, respectively. Temperature data are collated into seasonal means as follows: Winter (January – March), Spring (April – June), Summer (July – September), and Fall (October – December).

An examination of the deviations of seasonal mean water temperature at both shallow and deep locations north of Cape Cod (Southern Gulf of Maine) reveal that water temperature has generally been above average throughout the latter half of the 1990's and into the early 2000's. Similarly, seasonal mean water temperature has generally been above average throughout the latter half of the 1990's and into the early 2000's at both shallow and deep locations south of Cape Cod (Southern New England).

This warming trend is confirmed by surface water temperature data collected by the National Oceanic and Atmospheric Administration (NOAA) from 1922 to 2003 in Boston Harbor, Massachusetts. There has been a statistically significant increase in the annual mean surface water temperature in Boston Harbor over the last 80 years. In 2002, the annual mean surface water temperature in Boston Harbor was 13.9°C, a time series record high that is 5 degrees above the time series low in 1924, and 3.1 degrees above the time series mean 10.8°C.

MarineFisheries is concerned with the impact of increasing water temperatures on lobster along the Massachusetts coast; conclusions of the effect of temperature is yet to be determined. As the *MarineFisheries'* bottom water temperature time series continues to develop, *Marine Fisheries* intends to examine this trend in relation to lobster life history and commercial landings.

Summary

Improvement in water quality can be seen in many local embayments as wastewater treatment programs and point source control programs are targeted toward mitigation of contaminant problems. The MWRA has tracked improvement in indicators of water and sediment quality in its annual report "State of Boston Harbor". During the past decade, MWRA reports improvements in oxygen concentrations in near bottom waters of Boston Harbor, reductions in solid discharges to the harbor, reductions in metal discharges to the harbor, as well as other indicators of environmental quality. (http://www.mwra.state.ma.us/harbor/html/2002-09.htm).

These improvements are a positive sign for the quality of nearshore waters, but larger-scale influences (e.g., changes in water temperature and salinity) may alter environmental conditions. Systematic water quality sampling will track changes in conditions and provide quantitative data to develop management plans.

2. MAJOR DISCHARGES IN MASSACHUSETTS

The U.S. EPA has a permit database that includes National Pollutant Discharge Elimination System (NPDES) permit holders in Massachusetts. This section describes a subset of the entire database and identifies permits in coastal communities. Coastal Massachusetts communities were defined as municipalities that abut the coastal zone boundary as defined by CZM regulation (301 CMR 21.00). The available data did not allow an analysis of permits through time, so this assessment describes the 2003 status of the major and individual NPDES permits. As of 2003, there are 145 individual and 61 general NPDES permit holders in coastal Massachusetts communities.

Of the individual permits, 79 discharge directly to coastal waters and at least 33 of these are minor dischargers (less than one million gallons per day). The other individual permits discharge within the coastal watershed, including discharge to riverine systems.

Twenty-eight of NPDES permit holders are municipalities that discharge treated wastewater. An average of 472 million gallons of treated municipal wastewater directly enters tidal waters each day. Of these 28 facilities, two receive only primary treatment (Gloucester and Gosnold). All other facilities have at least secondary wastewater treatment.

There are ten large power-generating facilities that together are permitted to withdraw and discharge up to 4.5 billion gallons of cooling water every day from coastal waters. The discharged cooling water can be heated from 83 to 105˚F (28-41˚C) and can be 20 to 32˚F (-7-0˚C) greater than the ambient water.

Only eight major industrial dischargers in the coastal zone were retrieved by the search engine of EPA's PCS database. This is an under-representation of existing industrial discharges (e.g., Gillette was not included in the database and oil terminal permits were seriously underrepresented, Callaghan personal communication) and limit the description of industrial discharges to Massachusetts waters. Of the incomplete list of industrial discharges, five are stormwater discharges from industrial sites, two are process water discharges, and one is a cooling water discharge.

From 1992-2002, 228 individual NPDES permitted discharges in coastal Massachusetts communities were ended, either because the waste stream was consolidated, the company went out of business, or the project ended.

3. CONTAMINANT DISTRIBUTIONS IN SEDIMENTS AND SHELLFISH ALONG THE MASSACHUSETTS COAST

Regional studies of Massachusetts coastal waters have documented the spatial distribution of several classes of contaminants, including trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) in sediments and biota (National Research Council 1995; McDowell 1997). The relationship between contaminant inputs and the distribution of contaminants in sediments and biota largely reflect a gradient of near-shore areas, especially urban and industrialized areas, having the highest levels of contamination, and offshore areas having significantly lower concentrations.

The first U.S. Mussel Watch program (1976-1978) provided a regional assessment of contaminant distribution in bivalve samples from New England waters (Farrington et al. 1983; Goldberg et al. 1983). Data collected in this program documented the strong urban influence on contaminant distribution in mussel samples for both trace metal and organic contaminants. A recent review of a decade of data collected in the Mussel Watch component of NOAA's National Status and Trends Program (mid 1980s to mid 1990s) concludes that the concentrations of contaminants in bivalve samples are declining for many classes of contaminants (O'Connor 1998). Exceptions to this general conclusion are reflected in the data for organic contaminants and lead particularly at stations in urban areas such as Boston Harbor.

To a large extent contaminant distribution in sediments and biota reflect not only contemporary inputs but also a history of industrial activity. For example, chromium contamination in Salem Harbor (MA) - reflects a history of inputs from the tanning industry (NOAA 1991). Concentrations of other trace metals are elevated at other locations – Boston Harbor and Quincy Bay – and reflect a pattern of wastewater input and other industrial sources of contaminants to shallow water embayments (NOAA 1989; 1991). Hydrocarbon inputs may also vary spatially and temporally as a result of chronic municipal discharges, agricultural practices, oil spills and other point and non-point sources. In Massachusetts coastal waters, there are numerous locations that have received inputs of petroleum hydrocarbons from both chronic discharges and accidental spills (Boston Harbor, Buzzards Bay, etc.) (MacDonald 1991; Menzie-Cura & Associates 1991; NOAA 1991). The use of chlorinated pesticides in agricultural practices has declined since the early 1970s but traces of pesticide residues have been reported at locations within the Gulf of Maine with inputs from agricultural runoff (Hauge 1988; Larsen 1992). For NOAA National Status and Trends Mussel Watch samples, elevated concentrations of aromatic hydrocarbons, chlorinated pesticides, and other chlorinated hydrocarbons were noted in bivalve samples, especially in urban harbors and industrialized areas (NOAA 1989; Sowles et al. 1992).

Trophic transfer of contaminants to higher level predators and the human consumer are generally most significant for lipophilic contaminants such as chlorinated hydrocarbons, and other persistent contaminants. Shellfish closures and advisories based on chemical contamination are relatively few but include some examples from the New England coast, notably PCB contamination in New Bedford Harbor and dioxin contamination in Maine (McDowell 1997).

4. MONITORING PROGRAMS FOR THE MASSACHUSETTS COAST

Monitoring water and sediment quality is challenging. There are many programs within the region, nation, and worldwide that provide guidance on developing monitoring programs. When designing a monitoring program to assess environmental changes in coastal resources, three basic questions need to be addressed (NOAA 1998):

1. Are environmental conditions improving or deteriorating over space and time? If so, where and when?
2. Are changes related to human activities? Do some activities have a greater impact than others?
3. What actions can best correct existing problems or prevent future problems?

Monitoring programs for measuring the fate and effects of chemical contaminants in coastal ecosystems should be designed and executed to provide meaningful information on: (1) spatial distribution of contaminants; (2) temporal variability in contaminant distributions, as a result of both natural variability and changes in chemical use patterns or pollution abatement; and (3) the relationship of contaminant inputs to ecological consequences, including habitat alterations of valuable resources, and human health concerns. Current state and federal monitoring efforts in coastal waters of Massachusetts, however, are too limited in scope (both spatially and temporally) to meet these goals.

Ecological effects of contaminants in coastal environments include impairment of feeding, growth, development, and recruitment that may result in both alterations in reproductive and developmental success and changes in community structure and dynamics. The human health concerns of contaminated resources are obvious. Yet, it is difficult to ascertain the relationship between chronic responses of organisms to contaminated habitats and large-scale alterations in the functioning of marine ecosystems as well as large-scale contamination of fishery resources. The sensitivity of early developmental stages, the impairment of reproductive processes, and the long-term effects on populations suggest that chronic exposure to many contaminants may certainly alter the dynamics of populations, including populations of valuable commercial resources.

To better understand the fate and potential effects of contaminants in the Gulf of Maine ecosystem, the following parameters are often evaluated:

1. Define the sources of contamination for specific contaminants and determine the relative contribution of different point and non-point sources to loading of individual compounds. An inventory of every compound is not feasible but an assessment of a few highly persistent compounds such as PCBs, PAHs, and the polychlorinated dibenzodioxins (PCDDs) should be possible.
2. Determine the persistence, degradation rates, and biogeochemical cycling of specific contaminants in sediments at selected sites along the Massachusetts coastline. Determine the flux of specific compounds and the body burdens of resident organisms.
3. Using populations of indigenous bivalve species or demersal fish or lobster populations during seasons with limited migrations, define patterns of contaminant exposure and the relationship between exposure and changes in physiological condition or other parameters of biological change.

Such a program could lead to a better understanding of the causal relationship between input of specific contaminants and the relative ecological and human health risks associated with such inputs. Specific management issues that must be addressed, especially in consideration of the ecological and human health risks associated with chemical contamination, are the development of contaminant guidelines for benthic habitats. These should include consideration of guidelines for the disposal of contaminated dredged materials, development of interim sediment criteria, and the routine determination of concentrations of contaminants in harvestable resource species.

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